NATIONAL PROFESSIONAL EXAMINATIONS

MAY 09

98-MMP-A3 - Mineral Processing

DURATION : 3 hours

NOTES:

(1) This is a CLOSED BOOK EXAM. No notes or textbooks permitted.

(2) Candidates may use one of the approved Casio or Sharp calculators.

(3) Answer all questions except where otherwise noted.

(4) Show all calculations.

(5) If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

(6) The mark distribution is as follows:

Problem 1 (i) 6, (ii) 6, (iii) 4, (iv) 2, (v) 2, (vi, a) 6 , (vi, b) 3, (vii) 5 Total 34

Problem 2 (i) 8, (ii) 6, (iii) 4, (d) 2 Total 20 marks

Problem 3 6 marks each Total 30 marks

Problem 4 Total 16 marks

Bonus Question 2 marks

Unit conversions:

1 tonne = 1000kg = 2202.6 lb
1 ton = 2000 lb
1 inch = 2.54 cm = 25,400 microns (μm)

1. The publication *Milling in Canada* contains the following description of the copper flotation circuit at the Gibraltar Mine located in central British Columbia:

> The three grinding circuits each feed an individual flotation bank of 16 Denver 600H flotation cells. Rougher flotation is carried out at 42% to 44% solids and is operated at a pH of 9.6 to 10.2, with lime addition to the rod mill. Sodium isopropyl xanthate is added to the cyclone overflow as a flotation collector; Orform F-2 is added to the cyclone overflow as a frother.
>
> Concentrate from all three flotation cell banks are combined and pumped to a regrind circuit. The bulk regrind mill is 9.5 ft diam. by 14 ft long ball mill powered by a 670 hp motor in closed circuit with one 20 in. horizontal Krebs cyclone.
>
> The bulk regrind cyclone overflow flows by gravity to a column surge tank. A 10 in. by 8 in. SRL pump on the column surge tank pumps to one of two 7 ft by 40 ft high column flotation cells. The two column flotation cells operate in series with the tail of the first feeding the second column. The concentrate from the two columns grading 28% copper is combined and pumped to the concentrate thickener. The tails of the second column is pumped to a bank of sixteen 300H Denver flotation cells. The concentrate from the column scavenger flotation cells flows by gravity to the column feed surge tank where it combines with the regrind cyclone overflow. The tails of the column scavenger flotation cells flows by gravity to the final tailings box.

(i) Sketch the flow sheet of the flotation circuit described above. **(6 marks)**

(ii) If the feed grade is 0.31 % Cu and the copper recovery is 80% calculate the grade of the tailings (% Cu). **(6 marks)**

(iii) If the mill processes 30,000 tonnes per day of ore, calculate the tonnes of concentrate produced each day. **(4 marks)**

(iv) Calculate the % copper in pure chalcopyrite ($CuFeS_2$). **(2 marks)**

Given atomic weights:
Copper.....63.5
Iron.....55.8
Sulphur.....32.1

(v) If the only copper-bearing mineral in the ore is chalcopyrite, calculate the percentage of chalcopyrite in the copper concentrate.**(2 marks)**

(vi) If the economic factors for the mining and milling operation are:

mining cost $3.00/tonne of ore
milling cost $4.00/tonne of ore
concentrate freight $150/tonne
smelting charges...$250/tonne
operating days per year.....350

and payment is received for the copper contained in the concentrate at the rate of $5/kilogram, calculate

(a) the economic efficiency (in %) **(6 marks)**

(b) the net operating profit (i.e. revenues minus costs) in $ million/year **(3 marks)**

(vii) If the ore is ground to 95% passing 200 microns, using Gy's equation calculate the weight of sample required to maintain the sampling error to within ± 0.01% Cu, 95% of the time.

Gy's Equation $M = \frac{C\,d^3}{s^2}$ assume C = 60 g/cm^3 **(5 marks)**

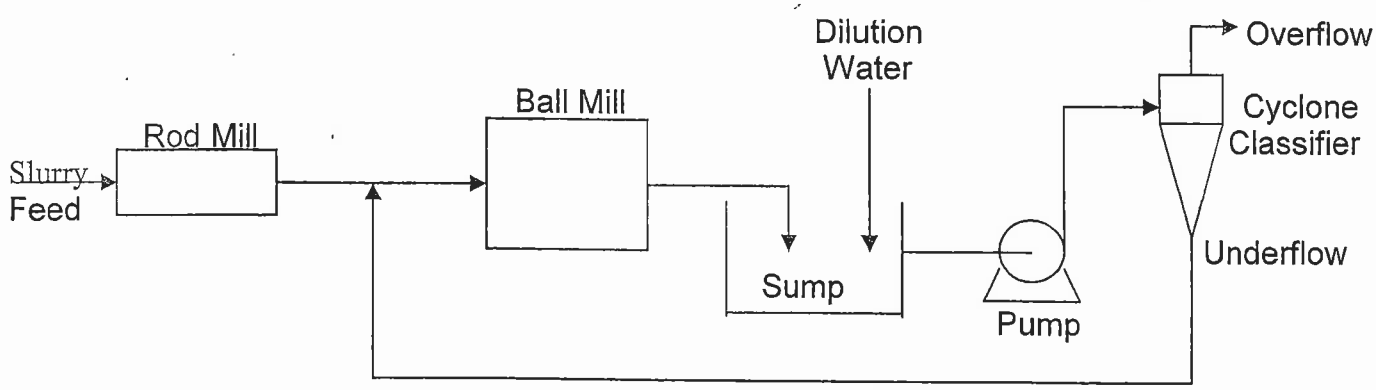

FIGURE 1. Layout of Grinding Circuit for Problem 2

2. A two-stage grinding circuit using a 3 m diameter, 5 m long rod mill in open circuit and a 3 m diameter, 3.5 m long ball mill in closed circuit with a cyclone classifier is used to grind 100 tons per hour of ore (SG 3.0). The circuit layout is illustrated in Figure 1 above. Assume that the circuit was sampled and the results were as follows:

	Percent - 200 mesh	Percent solids by weight	80 % passing Size Microns
Rod Mill Feed	5	80	4000
Rod Mill Discharge	15	80	900
Ball Mill Discharge	45	75	121
Cyclone Overflow	75	35	81
Cyclone Underflow	25	75	400

(i) Carry out a material balance and calculate the solids recirculating load (in %). **(8 marks)**

(ii) Calculate the tons/hour of dilution water added to the sump. **(6 marks)**

(iii) If the work index is 14, calculate the net power (kilowatts) required by the ball mill. **(4 marks)**
Bond's Equation:

$$W = \frac{10\,W_i}{\sqrt{P}} - \frac{10\,W_i}{\sqrt{F}}$$

(iv) Calculate the specific gravity of the cyclone underflow slurry. **(2 marks)**

3. Explain the similarities and differences between the following terms as they are related to mineral processing. Use sketches in your answers. **Answer any five (5) (30 marks)**

(i) Coagulation/flocculation
(ii) Jig/table
(iii) Upstream/downstream tailings dam
(iv) Frother/collector
(v) Gyratory/jaw crusher
(vi) Merrill-Crowe/carbon-in-pulp process
(vii) Autogenous/pebble mill
(viii) Magnetic/high-tension separator
(ix) d_{50}/d_{50c}
(x) cataracting/cascading medium

4. Short answer questions. **(Total 16 marks)**

(a) With reference to problem 2, if the circuit operator wishes to produce a finer product i.e cyclone overflow, list two appropriate control actions he/she might take?

(b) With reference to problem 2, calculate the *reduction ratio* of the rod mill.

(c) Why is the heap leaching of gold usually more economical than leaching in stirred tanks?

(d) The rate of flotation is usually described by the following equation:

$$R = Rl\,[\,1 - \exp(-kt)]$$

where R is the cumulative recovery of a given mineral species in time t

Define the meanings of k and Rl.

(e) List two mineral commodities produced in Canada that are routinely processed using Dense (Heavy) Medium Separation.

(f) *'The energy consumed in the size reduction is proportional to the area of new surface produced'.* Who proposed the above comminution theory? (choices: Bond, Griffith, Kick, Hukki or von Rittinger)

(g) In the equation:

$$X = \frac{d_{75} - d_{25}}{2d_{50}}$$

What is **X** known as, and what does it measure?

(h) Sketch the structural formula of sodium ethyl xanthate.

(i) What is the most abundant metal in the earth's crust?

Bonus Question (2 marks):

List two mineral commodities for which Canada has **no** mine production.

Marking Scheme

Problem 1 (i) 6, (ii) 6, (iii) 4, (iv) 2, (v) 2, (vi, a) 6 , (vi, b) 3, (vii) 5 Total 34

Problem 2 (i) 8, (ii) 6, (iii) 4, (d) 2 Total 20 marks

Problem 3 6 marks each Total 30 marks

Problem 4 (a) 2 (b)2 (c) 2(d) 2 (e) 2 (f) 1(g)2 (h)2 (i) 1 Total 16 marks

Bonus Question 2 marks